Jack B. Kelly
Liquefied Natural Gas
Line-haul Truck Project

Status Report
June 1997

U.S. Department of Energy

State of Utah Office of Energy Services
Jack B. Kelley, Inc.
Bruderly Engineering Associates, Inc.
Cryenco Sciences, Inc.

Introduction

On March 1, 1996, the Utah and Arizona energy officers along with Jack B. Kelley, Inc., Cryenco Sciences, Inc., and Bruderly Engineering Associates, Inc., formed together to perform a demonstration project of liquefied natural gas (LNG) fuels in heavy-duty line-haul tractor trailer trucks. This project entails collecting, analyzing and reporting data for LNG class-8 trucks, and a Diesel class-8 control vehicle.

The Alternative Motor Fuels Act of 1988, section 400BB, makes a commitment to demonstrate and evaluate the use of alternative fuels in heavy duty vehicles. Under this auspice, the National Renewable Energy Laboratory (NREL) has been designated to implement this section.

This goal of this program is to advance the commercial use of LNG in heavy-duty fleets, by demonstrating Original Equipment Manufactured natural gas trucks and provide public outreach services.

The demonstration started March 1996 and will last until October 1998. It consists of four main objectives. The first objective is to provide fleet operational analysis. The second objective, is to make vehicles available for emissions testing. The third objective is to develop training programs and present them to three target audiences. Lastly, the fourth objective is to provide reports on technical data LNG fuels and heavy-duty vehicle technology.

Overview of the Project

-Fleet Specifications:
The fleet being demonstrated comprise of ten Kenworth chassis with Cummins L10-300G engines, and one Navistar Chassis with Cummins L10- 300G engine, making this one of the biggest fleets of its kind. The control vehicle being used is the Navistar truck with a Cummins M11 engine. Currently at San Manual six Kenworth LNG, and one Navistar LNG truck are in service along with 19 Diesel Trucks. In addition four Kenworth LNG trucks will be demonstrated at a site to be determined.

-**Route Specifications**:
San Manual Arizona is the currently main station for the trucks. The primary duty of the truck is over the road hauling of acid in MC-312 trailers. Typical duty cycles' of these trucks are two eight-hour shifts a day. The route consists of mountain terrain with an average grade of 4%, and two lane highway traffic. Average speed is 50 miles per hour. Arizona temperatures average a high of 85 degrees and a low of 57 degrees. The summer average temperatures are 103.7 for the high, and 76.3 for the low.

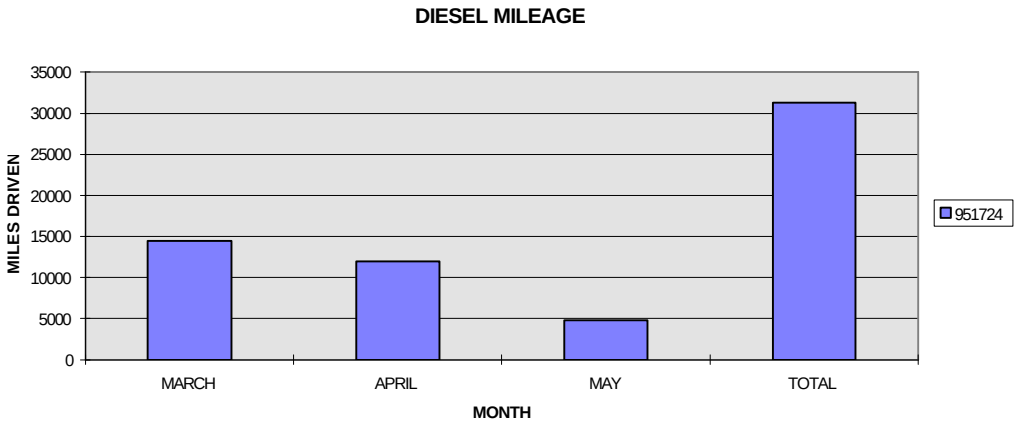
-Fueling Station:
San Manuel fuels the vehicles with LNG supplied from an ERVING (Equipment Refueling Vehicle Issuing Natural Gas). The ERVING Vehicle is designed to operate as a mobile refueling station. The ERVING mobile unit is fully self-contained. It can provide conditioned fuel, saturated to a level that will meet the demand of the fleet. The unit consists of a 4500-gallon TVAC (Thermal Vacuum) to store LNG, and a LNG skid. The skid is designed to transfer LNG to the vehicles through an electrically driven pump.

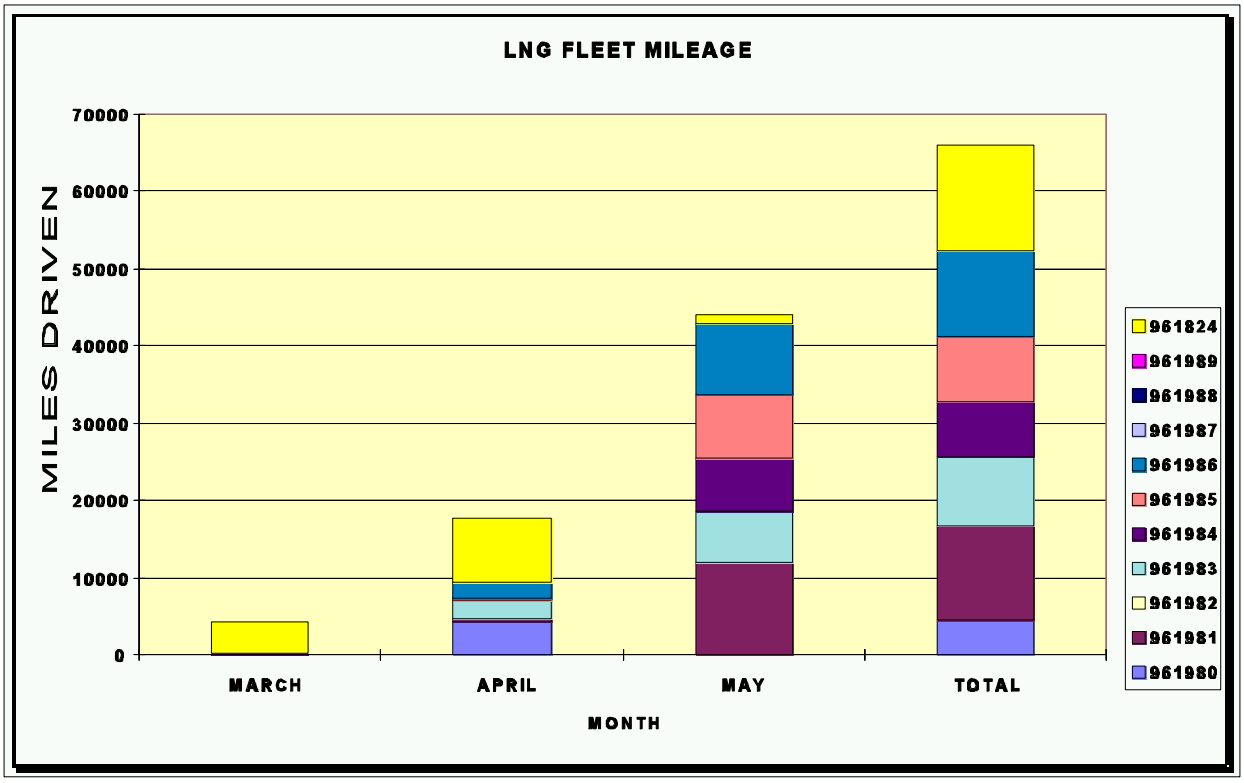
-**Maintenance Facilities**:
All routine maintenance such as oil changes, filter changes, preventive maintenance, general repairs and troubleshooting, is done at the facility in San Manual Arizona. The fully equipped indoor facility consists of two drive through bays and a tire bay. Five full time Mechanics work a split shift, to ensure the trucks stay on the road as much as possible. Typically the warranty covers the unscheduled maintenance, which Cummins performs. The Cummins dealer is on Prince Road in Tucson Arizona.

Vehicle Specifications

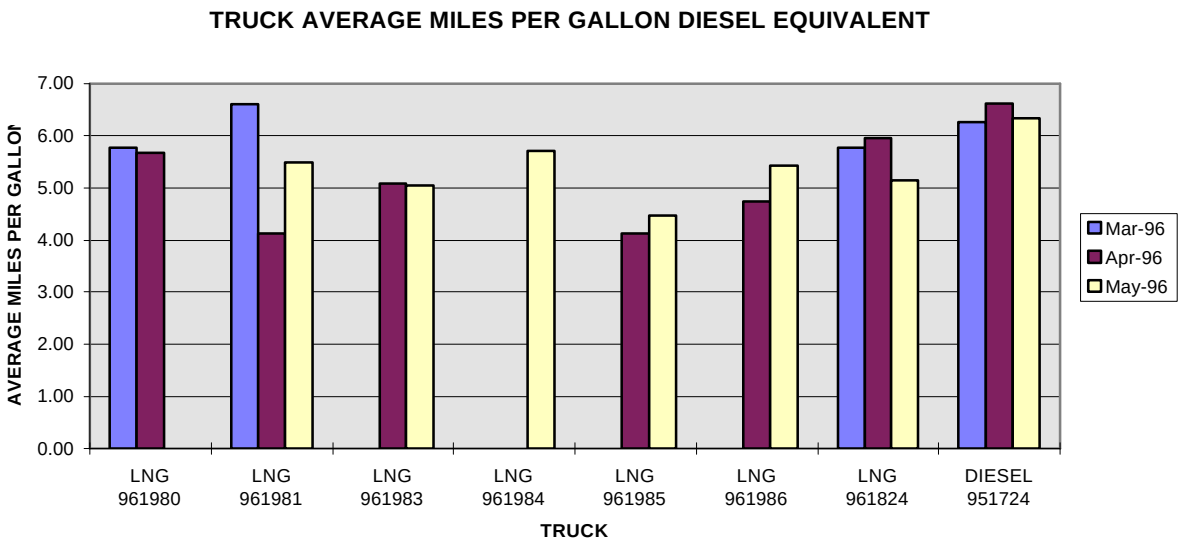
	KENWORTH	NAVISTAR LNG	NAVISTAR DIESEL
Model #/YEAR	T800/1996	9200/1995	9200/1994
ENGINE TYPE	CUMMINS L10-300G	CUMMINS L10-300G	CUMMINS M-11 300
OEM OR RETROFIT	OEM	RETROFIT	OEM
HORSEPOWER	300 @ 2100 RPM	300 @ 2100 RPM	350 @ 1800 RPM
TORQUE	900 LB-FT @ 1300 RPM	900 LB-FT @ 1300 RPM	1150 LB-FT @ 1600 RPM
TRANSMISSION	EATON-FULLER	EATON-FULLER	EATON-FULLER
NUMBER SPEEDS	13 FORWARD 2 REVERSE	13 FORWARD 2 REVERSE	10 FORWARD 2 REVERSE
COMPRESSION RATIO	9.5:1	9.5:1	16:1
LOW/HIGH AXLE RATIO	5:29	5:38	4:33
TOTAL GROSS WEIGHT	80,000 LBS.	80,000 LBS.	80,000 LBS.
TOTAL CURB WEIGHT	16,800 LBS.	16,800 LBS.	15,400 LBS.
FUEL TYPE	LNG	LNG	DIESEL
FUEL CAPACITY	200 GAL	200 GAL	94 GAL
LENGTH OF WHEELBASE	220 INCH	221 INCH	175 INCH

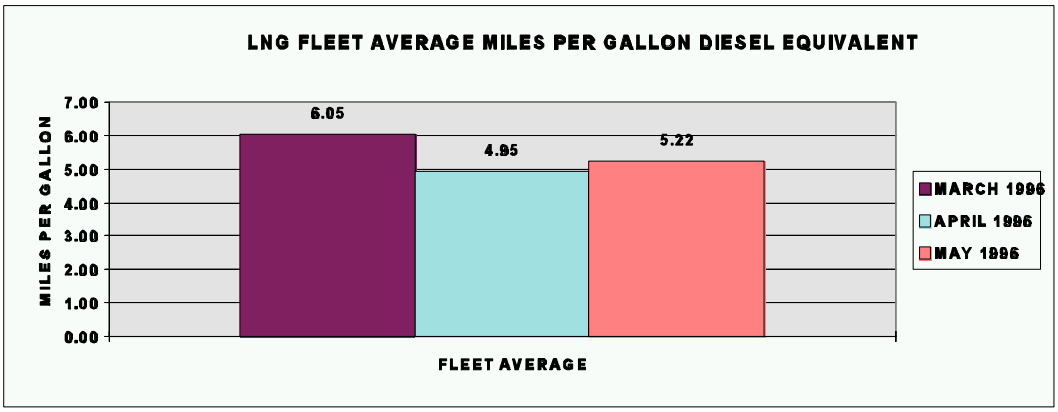
Operating Data



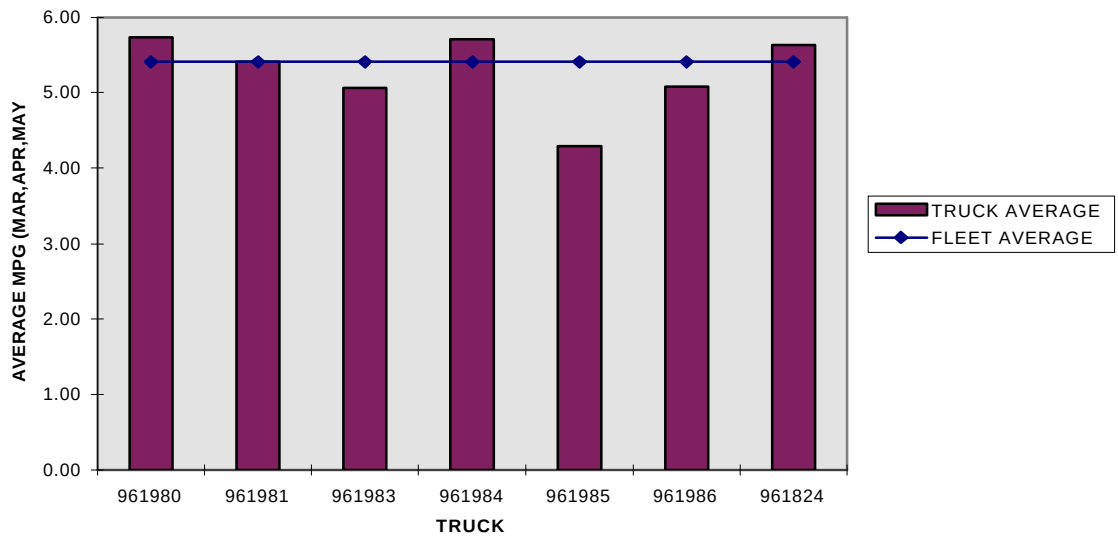


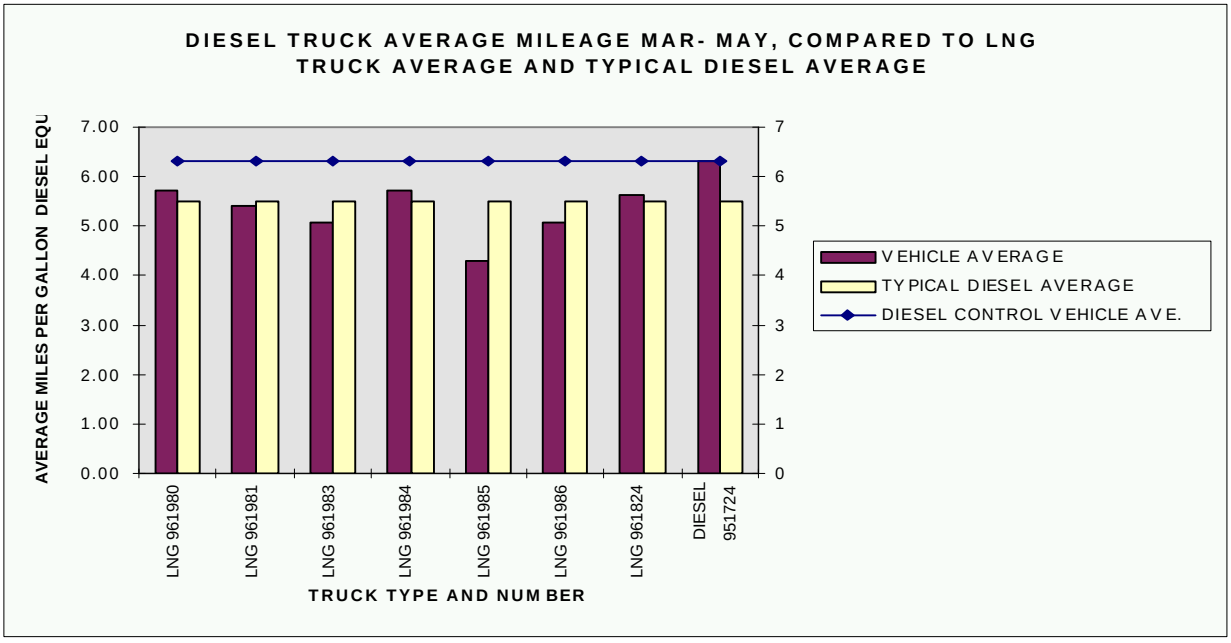
Fuel Economy





Comparisons





History and Problems

The LNG truck problems fall into four main categories' Fueling Problems, Fuel Tank Problems, Engine Problems and Methane Sensors.

1. Fueling Problems

Several trucks have had trouble with the fueling process. At times it will take up to two hours to fuel the vehicle; and on a few occurrences it took two or three tries to fill one tank. The fueling problems seem to be related to the amount of liquid kept in storage. Due to the cryogenic nature of LNG, when not used quickly, it warms up causing pressure to build in the TVAC storage container. As a result, when fueled the vehicle's tanks are unable to maintain proper pressure. When this occurs, the max differential of the TVAC and Vehicle Tank is reached causing the LNG pump to prematurely shutdown. This problem is being analyzed. One solution is that the problem will correct itself when all the trucks are running full duty cycles and they are consuming more fuel. This will decrease time the fuel is in storage.

Another problem has been that is being investigated is the reliability of the fuel gauges, and the lack of a vapor recovery line. This is causing a problem insuring the trucks are being fueled properly.

2. Fuel Tank Problems

Vehicle 961980 had a crack in the fuel tank. Cryenco Sciences Inc is repairing the fuel tank. A second fuel tank is being installed on 961824. This truck has been down awaiting maintenance.

3. Engine Problems

A defect was discovered in the throttle actuators used on all the Kenworth trucks, with the L10-300G engines. The Throttle actuators manufactured by Woodward Flotech, had a defect that causes uncommanded throttle condition. Under these conditions, without warning, the operator could experience loss of throttle control and subsequent engine acceleration. The vehicles were taken out of service on May 14, 1996 and were all repaired by May 18, 1996.

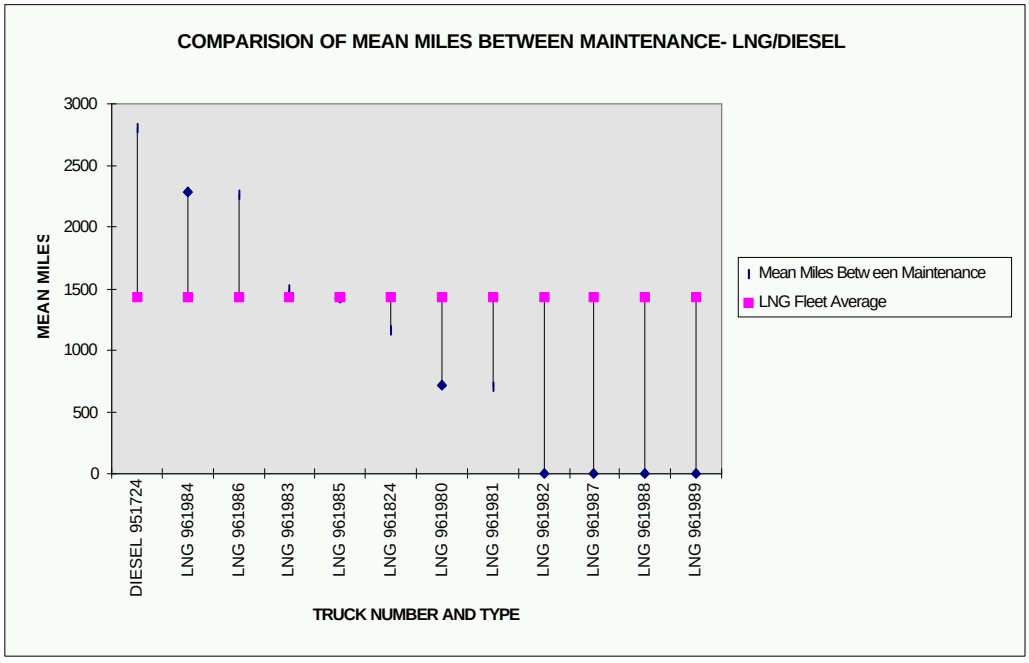
The Kenworth trucks have also blown out O-rings on the burst panel of the intake manifold. When this occurs, it causes the engine to backfire more frequently and causes difficulty with throttle control. This problem was presented to Cummins Engine Co. The determination was made that the O-ring burst panel on the intake manifold, is not necessary and they will ship parts so they can be blanked off.

A loss of power problem has occurred on several trucks, primarily in the afternoon. This problem seems to relate to the ambient air temperature in Arizona this time of year. The problem has been discussed with Cummins and they are researching all avenues for a solution to the problem.

4. Methane Sensors

All the Kenworth trucks had methane sensors wired incorrectly. The four vehicles currently in Amarillo Texas, were rewired by the local Kenworth Dealership. The procedures for repairs were sent to Arizona for the other six.

Mean Miles between Maintenance April -May 1996



*Note four trucks 961982, 961987, 961988, 961989 are not in service yet, but have had maintenance performed

Maintenance Incident Breakdown Apr-May 1996

KENWORTH T800B AND NAVISTAR 9200 TRUCKS WITH CUMMINS L10-300G ENGINE, NAVISTAR DIESEL 9200 WITH CUMMINS M-11 ENGINE.

TRUCK NUMBER	961824	961980	961981	961982	961983	961984	961985	961986	961987	961988	961989	951724	INCIDENT
MANUFACTURE	Nav	KW	KW	KW	KW	KW	KW	KW	KW	KW	KW	Nav-Diesel	LNG
IN SERVICE DATE	Oct-95	4/8/96	4/4/96	TBA	4/21/96	5/2/96	4/29/96	4/15/96	TBA	TBA	TBA	Oct-94	TOTALS
0 Whole System	1	1	0	0	0	1	1	2	1	0	0	1	**7**
1 Engine and Engine Equipment	0	1	1	1	3	1	1	1	1	1	1	0	**12**
2 Main transmission and clutch	0	0	0	0	0	0	0	0	0	0	0	0	**0**
3 Front axle and equipment	1	0	0	0	0	0	0	0	0	0	0	1	**1**
4 Rear axle and equipment	0	1	0	0	0	0	0	0	0	0	0	0	**1**
5 Tires, wheels and rims	3	0	0	0	0	0	1	1	0	0	0	1	**5**
6 Frame and equipment	0	0	0	0	0	0	1	0	0	0	0	1	**1**
7 Fuel Tanks and equipment	2	2	1	0	1	0	1	0	0	0	0	0	**7**
8 Cab and Equipment	0	1	2	1	1	1	1	1	1	1	1	1	**11**
9 Lights and Signals	0	0	1	0	1	0	0	0	0	0	0	0	**2**
10 Air equipment	1	0	1	0	0	0	0	0	0	0	0	1	**2**